Identified charged hadron production in Cu+Cu at √s_{NN} = 22.5 and 62.4 GeV in PHENIX

Tatsuya Chujo for the PHENIX collaboration



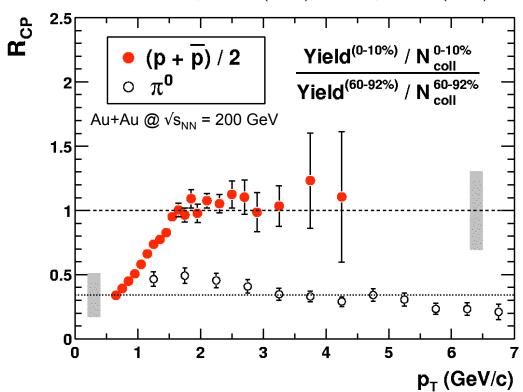


Introduction



~ Baryon Anomaly at RHIC ~

PHENIX: PRL 91, 172301 (2003), PRC 69, 034909 (2004)



Nuclear Modification Factor

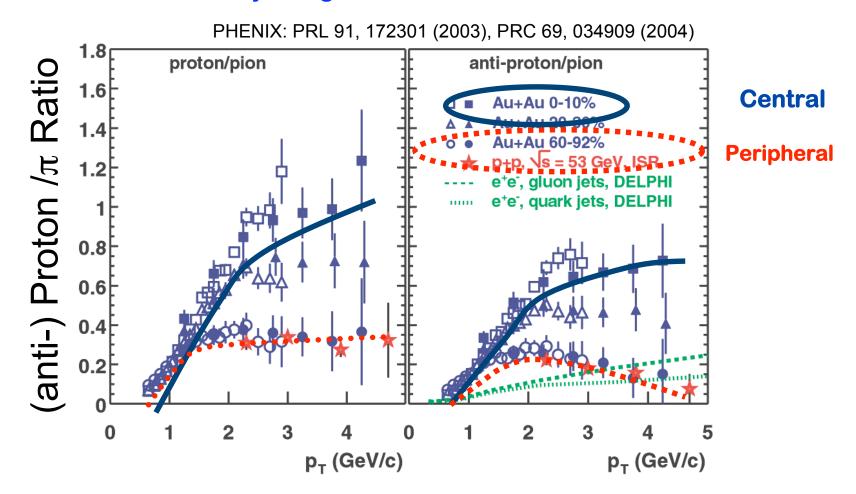
$$R_{AA}(p_{\tau}) = \frac{yield(AuAu)/N_{coll}}{yield(pp)} \sim R_{CP}$$

- In Au+Au √s_{NN} = 200 GeV central collisions:
 - Pions: Strong suppression of yields above $p_T \sim 2$ GeV/c, due to jet quenching effect.
 - Protons: No suppression for at intermediate p_T (2-5 GeV/c).
- Called "Baryon anomaly at RHIC".
- Quark recombination models reproduce the data qualitatively.

p/π ratios in Au+Au 200 GeV



More (anti) baryons than pions at moderate p_T (2-5 GeV/c). Does not look like vacuum jet fragmentation.



Where is the onset of the baryon anomaly at RHIC?

→New Cu+Cu data at lower √s_{NN} may give an answer...

Data Analysis

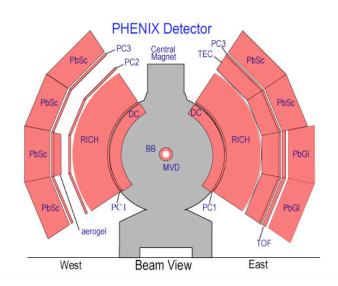


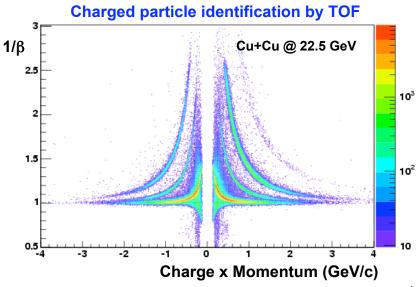
Data set:

- RHIC Run-5 (2005), measured by the PHENIX experiment.
 - Cu+Cu at 22.5 GeV.
 - Cu+Cu at 62.4 GeV.

Detectors:

- Drift Chamber, PC1, BBC and TOF for PID charged analysis.
- Centrality:
 - Subdivided minimum bias triggered events, based on BBC charge (62 GeV), or the number of PC1 hit (22 GeV).
- Corrections:
 - Geometrical acceptance, in flight decay.
 - NOTE: No weak decay feed-down correction applied.





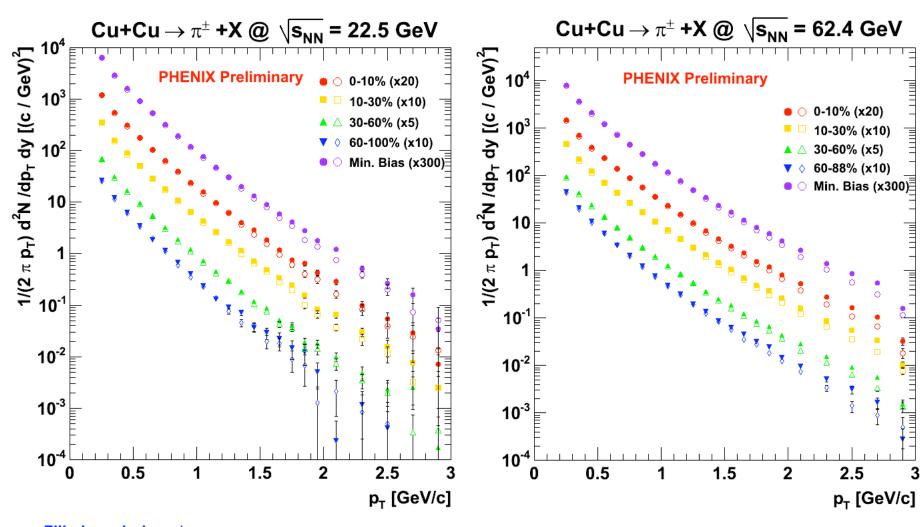
Results



- p_T spectra in Cu+Cu at √s_{NN} = 22.5 and 62.4 GeV.
- 2. p/π⁺ and p/π⁻ ratios vs. p_T.
- 3. Nuclear modification factor: R_{AA}.

p_T spectra for pions

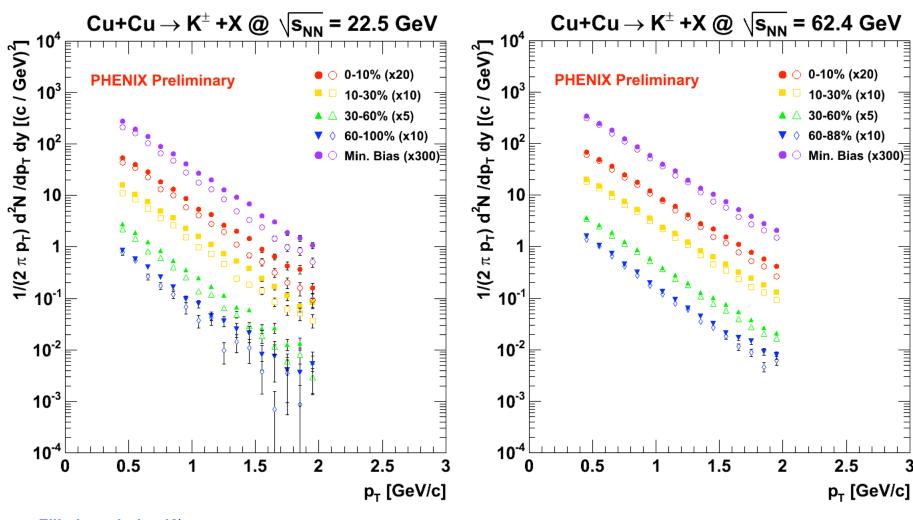




Filled symbols : π^+ Open symbols : π^-

p_T spectra for kaons

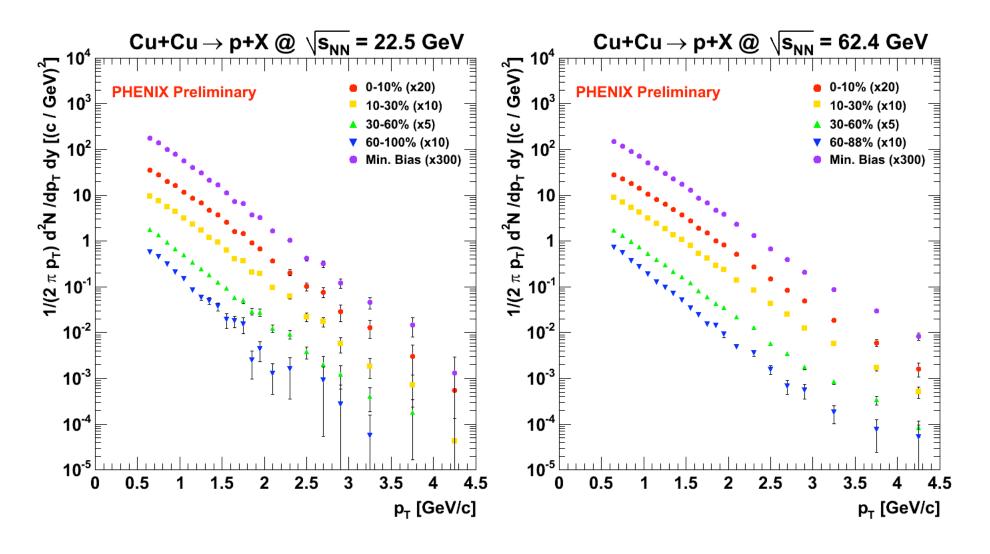




Filled symbols : K⁺ Open symbols : K⁻



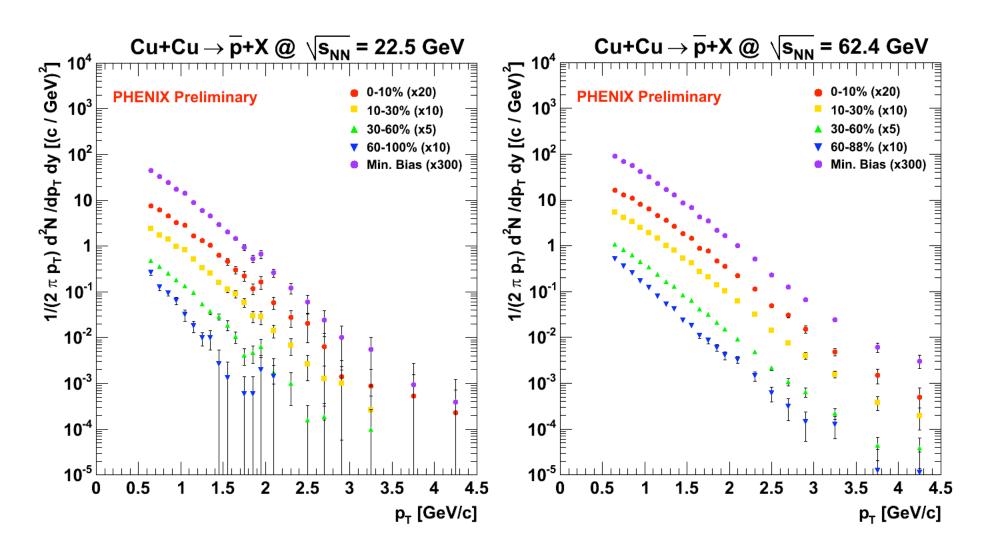
p_T spectra for protons



^{*} No weak decay feed-down correction applied

PHENIX

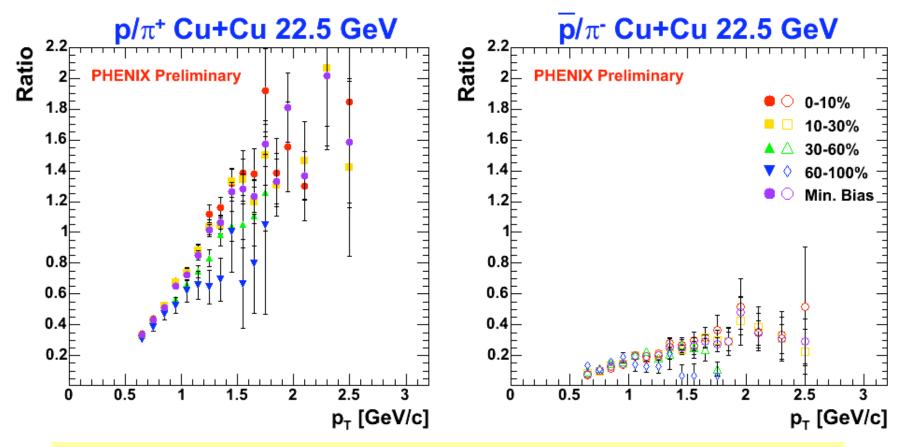
p_T spectra for antiprotons



^{*} No weak decay feed-down correction applied

p/π in Cu+Cu 22.5 GeV

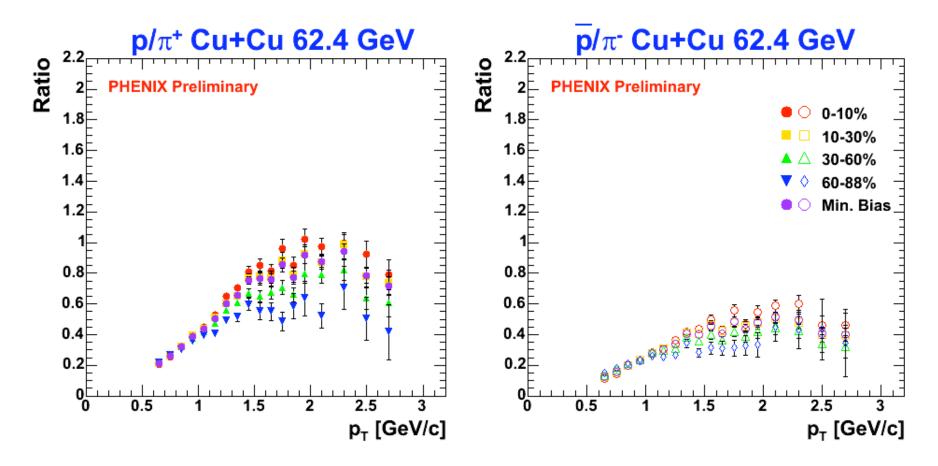




- Larger p/ π ⁺ ratios than those in Au+Au 200 GeV (0.5 @ p_T = 1.5 GeV).
 - Affected by the spectator protons (not produced protons) at lower $\sqrt{s_{NN}}$.
- \overline{p}/π^- ratios are ~0.3-0.4 at p_T = 2 GeV/c, which is close to the fragmentation expectations in p+p.
 - Almost no centrality dependence.

p/π in Cu+Cu 62.4 GeV

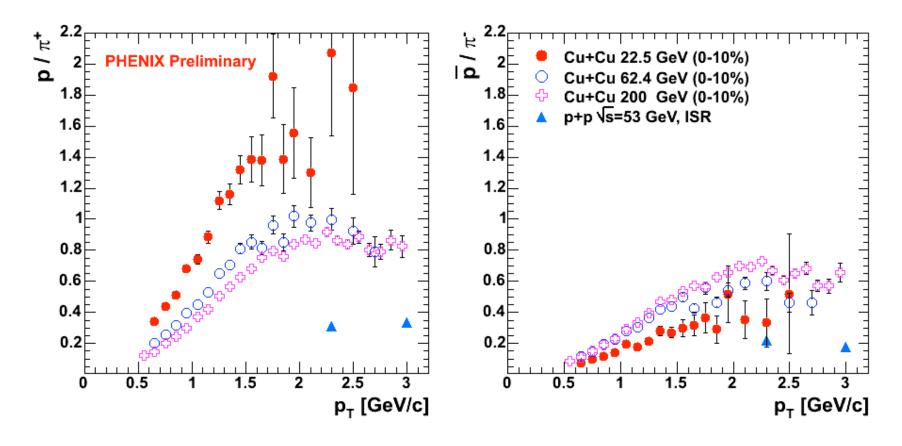




- p/π^+ ratios are reduced, compared to those in Cu+Cu 22 GeV.
- \overline{p}/π^- ratio in most central collisions reaches R=~0.6 at p_T = 2 GeV/c.
 - Centrality dependence is seen.
 - Peripheral pbar/π-: consistent with p+p value.

Beam energy dep. in Cu+Cu

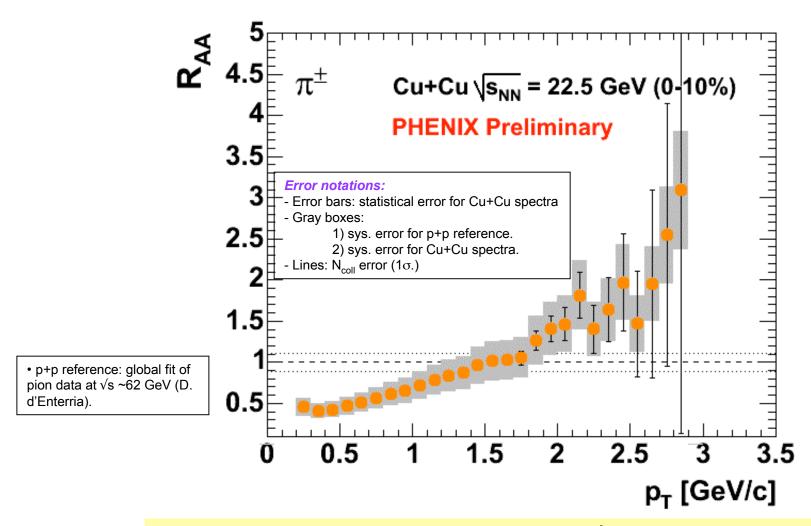




- p/π^+ ratio: decreasing as a function of $\sqrt{s_{NN}}$.
- \bar{p}/π^- ratio : increasing as a function $\sqrt{s_{NN}}$.
 - Cu+Cu 22.5 GeV central data reaches the p+p values.
 - Cu+Cu 62.4 GeV central data is higher than that in 22.5 GeV.

R_{AA} for pions (22 GeV)

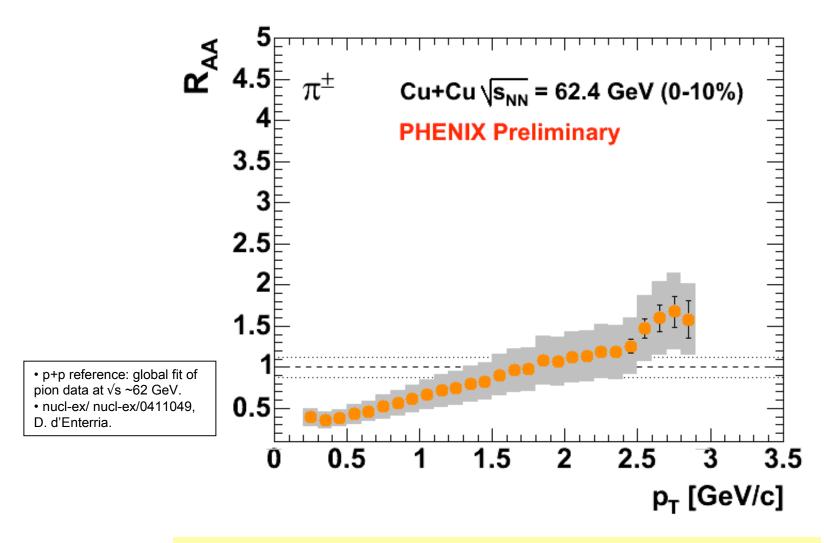




- p+p reference: global fit of pion data at √s ~22 GeV in p+p.
- R_{AA} is ~1.5 at p_T = 2 GeV/c, no suppression.

R_{AA} for pions (62 GeV)

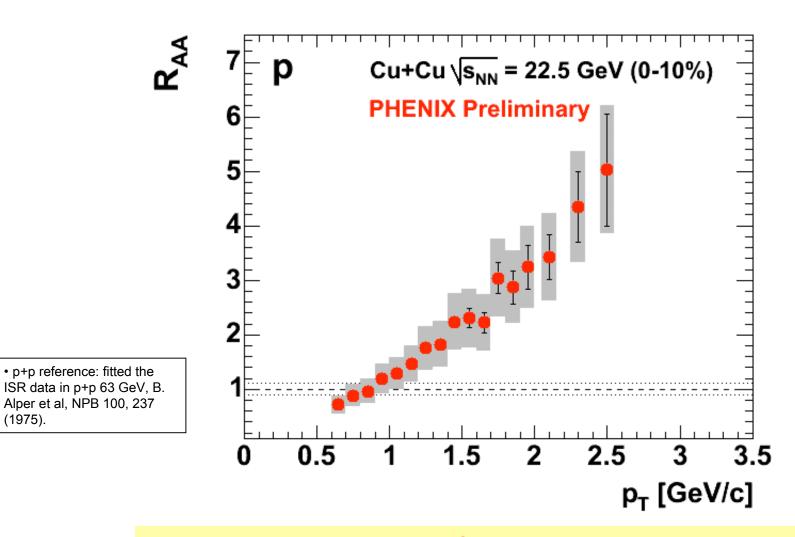




• Similar, might be slightly smaller than that in 22 GeV.

R_{AA} for proton (22 GeV)

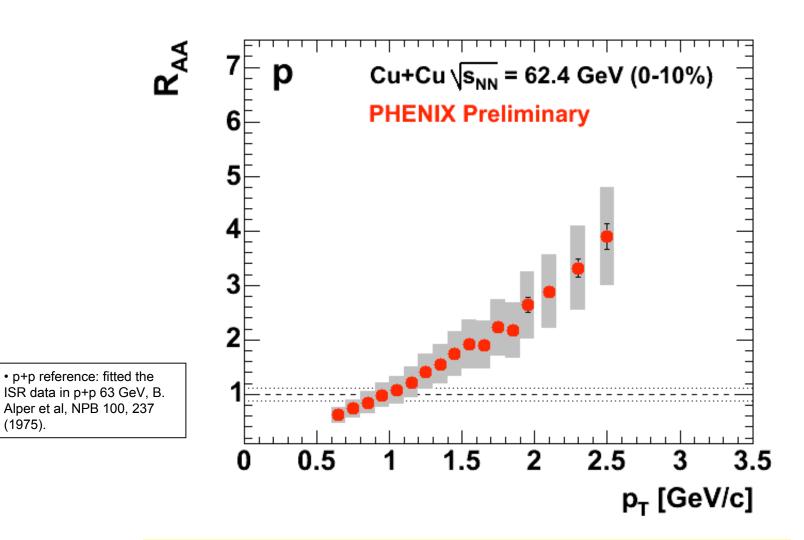




• Larger than pions significantly, which suggests the large contributions of spectator protons.

R_{AA} for proton (62 GeV)

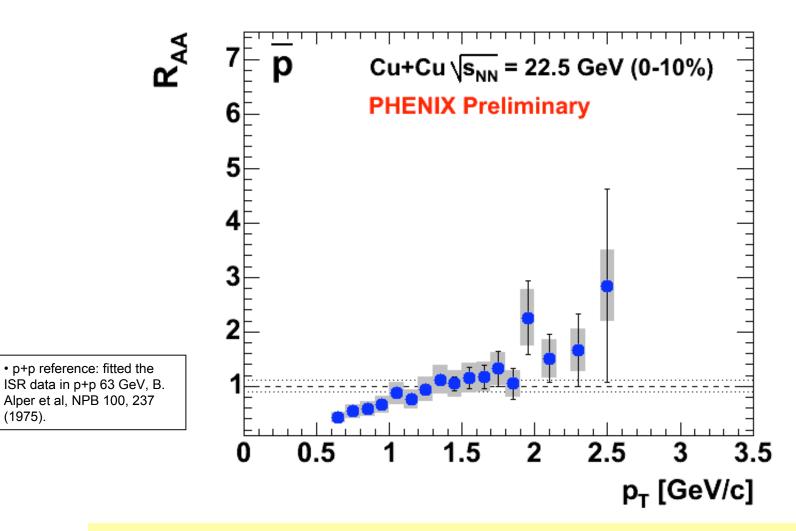




• Similar as in 22.5 GeV, but slightly smaller value.

$R_{\Delta\Delta}$ for antiproton (22 GeV)

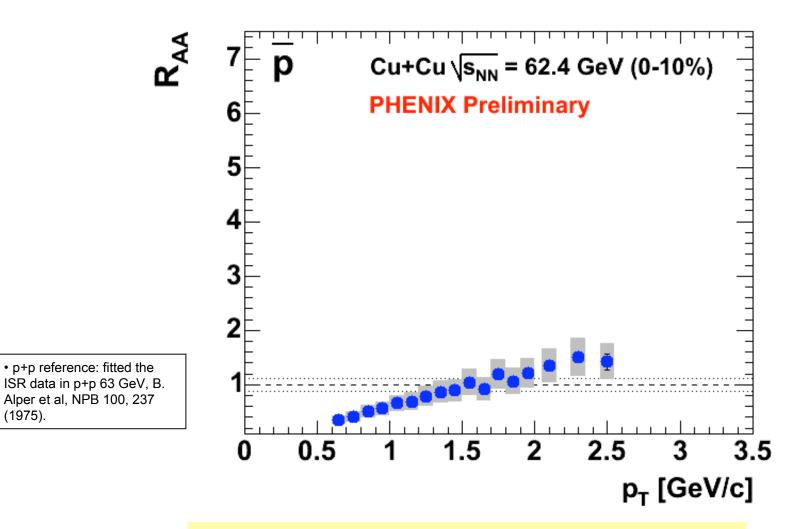




- Different p_T dependence from protons.
- R_{AA} ~ 1 (similar to pions' R_{AA}), binary collision scaling worked?

R_{AA} for antiproton (62 GeV)





Similar to that for 22 GeV (and also pion's R_{AA}).

Summary



Measured p_T spectra for π^{\pm} , K[±], p, \overline{p} in Cu+Cu at $\sqrt{s_{NN}}$ = 22.5 and 62.4 GeV in PHENIX.

- p/π⁺ ratio : decreasing as a function of √s_{NN} in Cu+Cu.
 - Suggests a significant contribution of spectator protons (not by the produced protons) in lower energies Cu+Cu.
- \bar{p}/π^- ratio : increasing as a function $\sqrt{s_{NN}}$ in Cu+Cu.
 - Cu+Cu 22.5 GeV shows that there is (almost) no centrality dependence, and central Cu+Cu already reaches to the p+p values.
 - Cu+Cu 62.4 GeV central data is higher than that in 22.5 GeV, centrality dependence is seen.
- R_{AA}
 - Particle type dependent.
 - π: no suppression at both 22.5 and 62.4 GeV in Cu+Cu.
 - p: enhanced (mostly due to the spectator nucleons).
 - \bar{p} : binary scaling, very similar to pion's R_{AA} .

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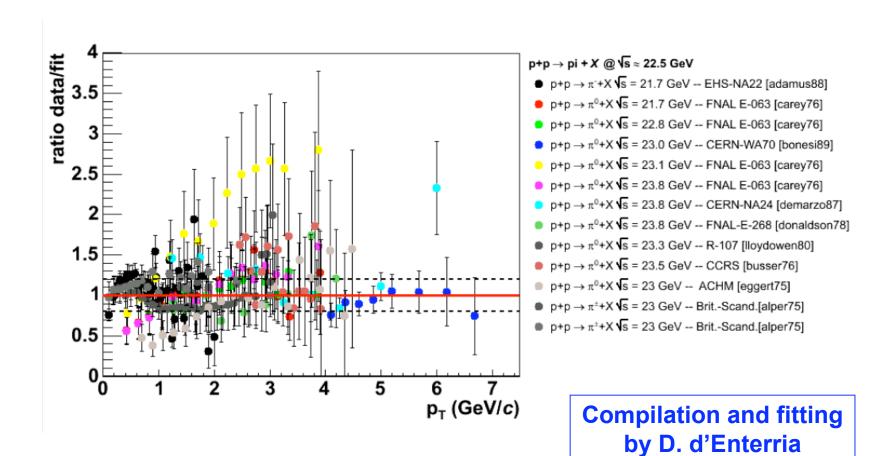
*as of March 2005



Backup Slides

p+p fit at \sqrt{s} = 22.5 GeV (pions)





R_{AA} for π⁰ in Cu+Cu 22.5 GeV PH^{*}ENIX



PbSc (0-10%)

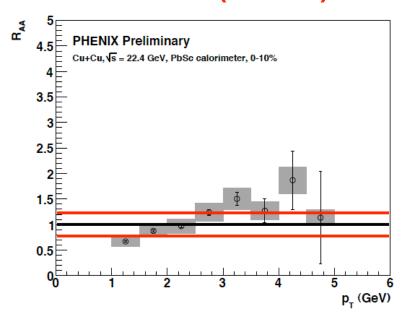


Figure 10: R_{AA} for the PbSc calorimeter and the Centrality Class 0-10%

PbGI (0-10%)

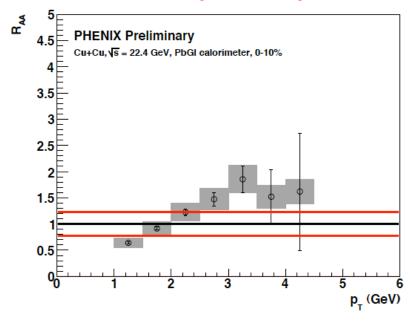


Figure 14: R_{AA} for the PbGl calorimeter and the Centrality Class 0-10%

SPS and AGS



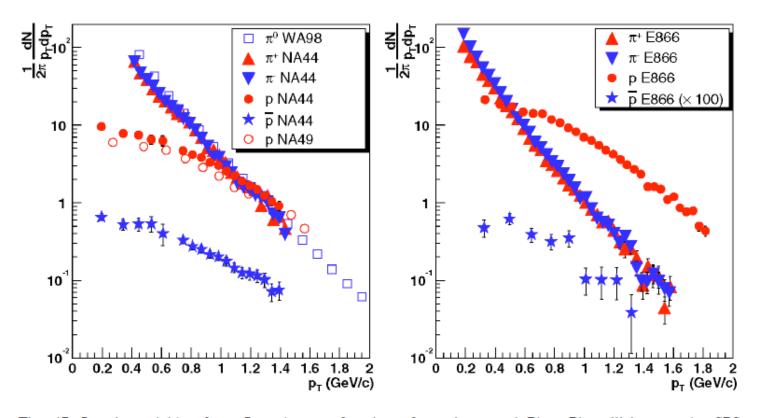
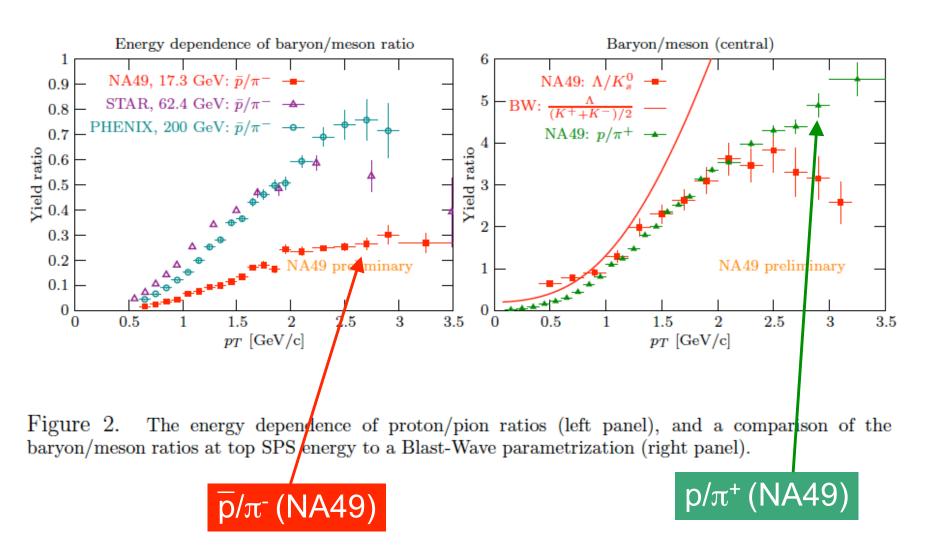


Fig. 47. Invariant yields of p, \bar{p} , and π as function of p_T in central Pb + Pb collisions at the SPS $(\sqrt{s_{NN}} = 17 \text{ GeV})$ (left panel) and in central Au + Au collisions at the AGS $(\sqrt{s_{NN}} = 5 \text{ GeV})$ (right panel). The \bar{p} spectrum from the AGS is scaled up by a factor 100. All data are at mid-rapidity $(y - y_{\text{em}} \approx 0)$ and are from W98 [163], NA44 [226], NA49 [227], and E866 [228,229].

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NA49 data

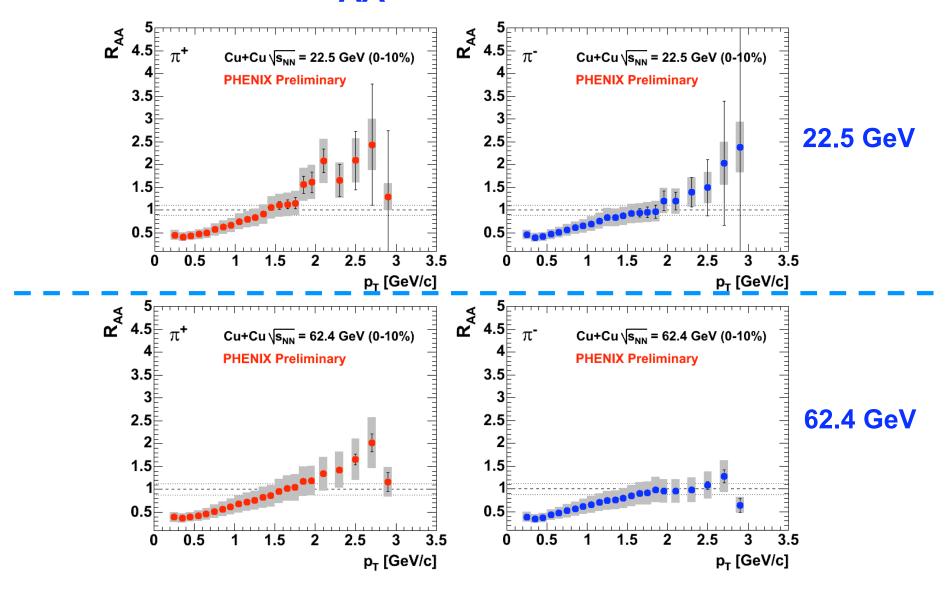




NA49 collaboration, nucl-ex/0510054

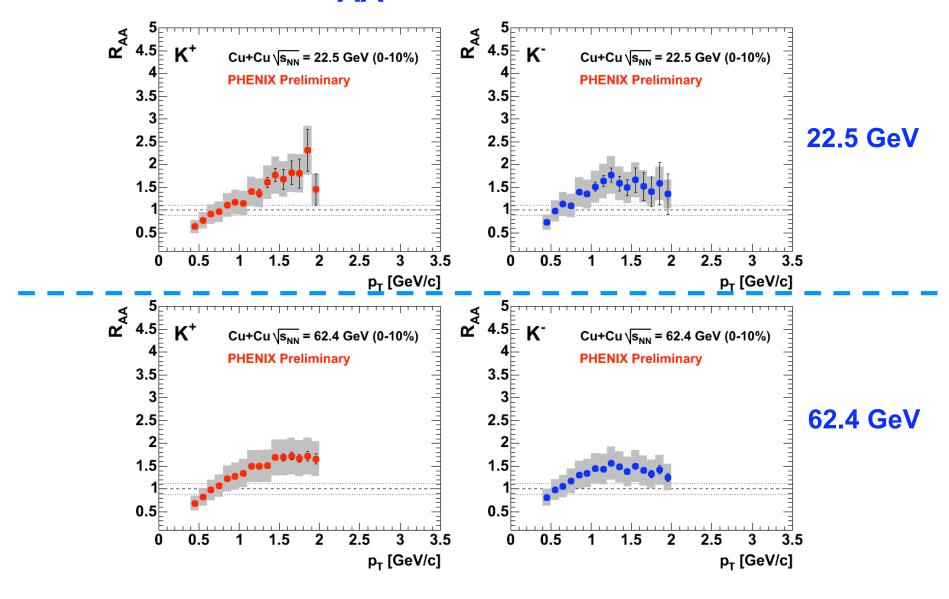
R_{AA} for pions





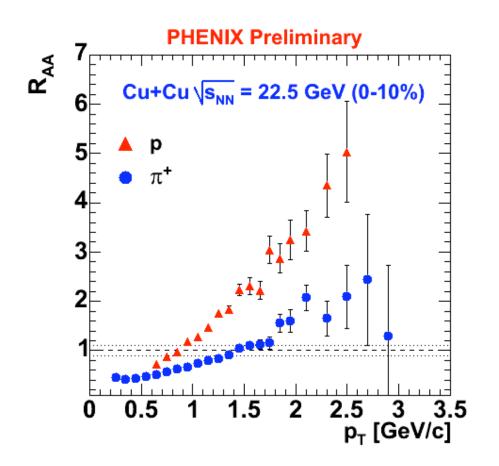
R_{AA} for kaons

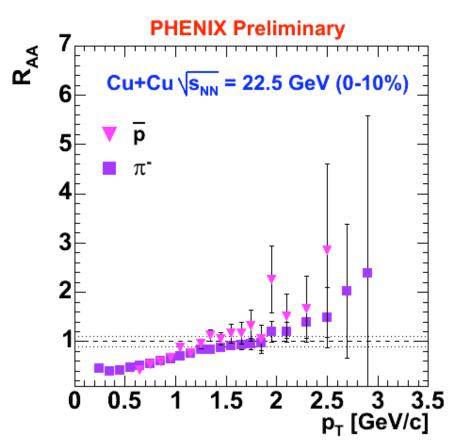




R_{AA} summary (22 GeV)

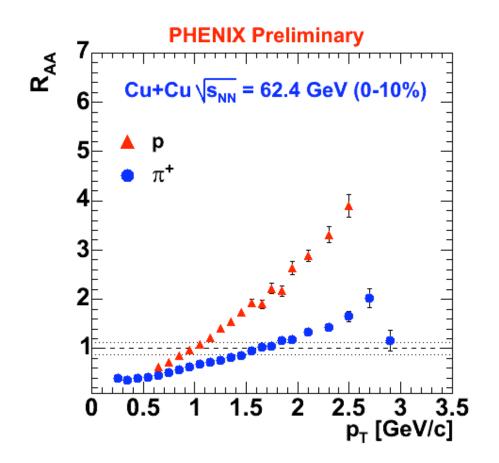


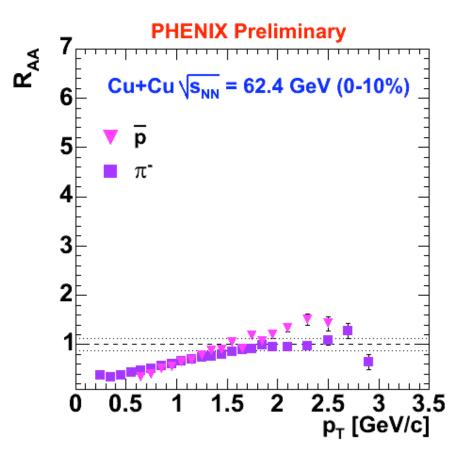




R_{AA} summary (62 GeV)

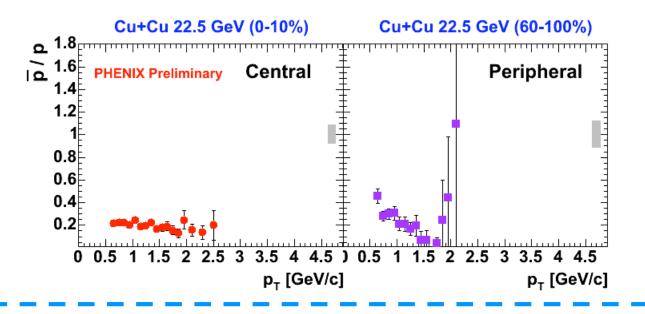




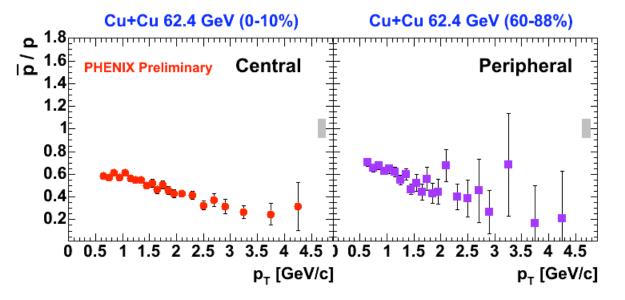


p/p ratio vs. p_T





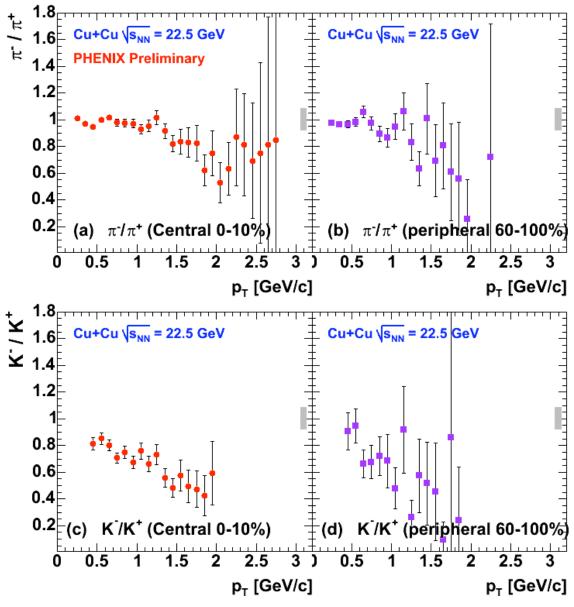
22.5 **GeV**



62.4 GeV

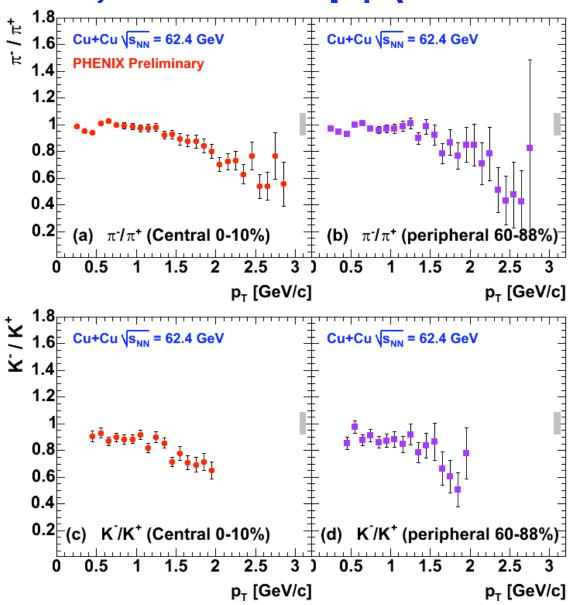
π^{-}/π^{+} , K⁻/K⁺ vs. p_T (22.5 GeV)





π^{-}/π^{+} , K⁻/K⁺ vs. p_T (62.4 GeV)



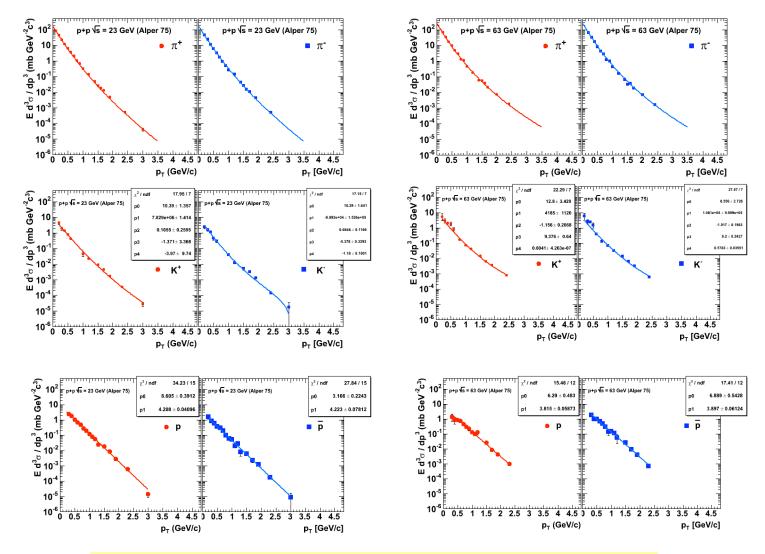


p+p reference data (with fit)



23 GeV

63 GeV



Kaons and protons: Fit results of ISR p+p 63 GeV data. B. Alper et al, NPB100(1975)237. pions: global fits of p+p data, e.g. nucl-ex/0411049, D. d'Enterria.